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PHYSICAL AND MECHANICAL PROPERTIES OF OSB (ORIENTED STRAND BOARD) PANELS PRODUCED WITH *PINUS TAEDA* L. (PINACEAE)

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Abstract: The study aimed to evaluate the physical and mechanical properties of OSB panels produced with Pinus taeda wood. In the physical part, two treatments were adopted: a. particles produced from whole logs and b. particles from lamination residues (remainder roll). Physical properties were tested: density, humidity, water absorption at 2 and 24 hours and thickness swelling at 2 and 24 hours. There was a significant effect of particle origin on all tested properties, with the exception of moisture content. Panels made with particles from waste rolls showed lower density. The properties of AA2h, AA24h, IE2h and IE24h were influenced by the origin of the particle. The panels produced with particles from the waste roll showed higher rates of AA and IE. In the mechanical part the same treatments were adopted. The ratio for particle layers: 30:40:30. The density adopted for the panels was 0.65 g/cm3. A 6% resin based on phenol formaldehyde (PF) was used, in relation to the dry mass of the particles. The following pressing parameters were adopted: a temperature of 180 °C, pressing time of 8 minutes and pressure of 30 kgf/cm2. The mechanical properties tested were: internal bonding, modulus of rupture and modulus of elasticity in two directions: parallel and perpendicular. All the average values of the technological properties, for both treatments, were higher than those specified by the CSA Standard (1993), therefore it is recommended to use the lamination residues in the production of OSB panels.
Keywords: technological properties, whole log, rest roll, engineered product.

INTRODUCTION

OSB-type panels are formed by multiple thin and long particles oriented in one direction, resulting in panels with three layers oriented perpendicularly, one after the other (Surdi et al. 2015). The geometry of the "strands" particles has a greater length/width ratio, providing less dimensional stability and greater resistance to static bending (Maloney, 1996). In recent years its applications have increased; mainly in: load-bearing walls, roofs, floors, beam components, among other applications (Mendes et al 2013). In Brazil, the total area of planted trees was 9.55 million hectares, with Eucalyptus trees in 78% and Pinus in 18% (IBÁ, 2021).

Pine wood is used as raw material for the production of: paper and cellulose, solid wood products, charcoal, panels and other purposes in the Brazilian wood sector. However, it is possible to use it in the production of OSB from inferior quality wood and even forest residues, as long as they have dimensions that allow the production of flakes (Cabral et al. 2006).

However, there is a very large search for raw material for different purposes, so there is a need to look for other sources that can be used for forestry production, such as waste from lamination such as the rest roll, to generate particles. This research aimed to evaluate the physical and mechanical properties of OSB panels, produced with wood from *Pinus taeda*.

MATERIAL AND METHODS

COLLECTING THE MATERIAL AND OBTAINING THE PARTICLES

Pinus taeda trees were collected in the municipality of Sengés, State of Paraná (Brazil), aged 35 years. They were slaughtered from the three individuals, sectioned into short logs. In addition, four logs were selected from other trees, cut with a band saw to obtain boards in a tangential direction, with a length of 2.40 m. Afterwards, wood blocks measuring 90.00 mm in length were obtained, in the longitudinal direction of the fibers for the production of "strand" type particles (wood particles from the entire log: Treatment "T1"), finally, everything was transported to the Laboratory of Lamination and Wood Panels-LLAPAM of the Superior School of Agriculture Luiz de Queiroz-ESALQ/USP, Piracicaba, São Paulo-SP for mechanical processing.

The four logs were processed to obtain particles from the residues of the lamination process (remainder roll), which is considered the "T2" Treatment. Next, the logs were softened in a tank with water at a temperature of 60 °C for 24 hours and processed in a rolling mill on an experimental scale to produce blades with a rest roll of 20 cm in diameter.

The lamination residues (remainder roll) were transformed into "strand" type particles, which were produced with a particle generator, with a 4-knife rotating disc. The particles had dimensions of 90 mm x 25 mm x 0.6 mm (length, width and thickness). This procedure was performed for both treatments. The particles were deposited on a plastic canvas, on the floor, in the open air until they reached a moisture content of around 18%, and then were transported to a laboratory oven at a temperature of 60 °C until they reached a humidity of around 3 to 4%.

A completely randomized design (CDI) was adopted with two treatments: T1: 100% whole log particles and T2: 100% lamination waste particles (remainder roll). To verify the effect of the treatments on the properties of the panels produced, an analysis of variance was carried out and, later, the Tukey test at a probability level of 95%.

PRODUCTION OF OSB TYPE PANELS

The following ratio was adopted for the layers of particles: 30:40:30. Each layer was arranged perpendicular to the other. The particle mattress was produced in a wooden forming box with 15 divisions made of iron sheets and a distance between them of 40 mm. The nominal density adopted for the panels was 0.65 g/cm3. Resin based on phenol formaldehyde (PF) was used. The resin was applied at a concentration of 6% in relation to the dry mass of the particles, using a rotating drum (gluing machine), which had a compressed air gun to sprinkle the particles homogeneously.

The final dimensions of the panels were 560 mm x 560 mm x 15.7 mm (length x width x thickness). Then, the panels were pre-pressed in a hydraulic press and shaped in an automated press, adopting the following pressing parameters: temperature of 180 °C, pressing time of 8 minutes and pressure of 30 kgf/cm2. After this step, the panels were arranged in a vertical position until they reached equilibrium temperature.

The following physical properties were determined: density, humidity, water absorption (AA) and thickness swelling (IE) at 2 and 24 hours, according to the standard guidelines (ASTM 2016)

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RESULTS AND DISCUSSION

PHYSICAL PROPERTIES

The results obtained for the physical properties of the panels are shown in Table 1.

It is observed that there was a statistical difference for the density of the panels (Table 1). For those made with particles from the whole log (IT), an average value of 0.75 g/cm3 was obtained, with higher density for those produced with residues from the remaining log, which showed an average value of 0.69 g/cm3. Wood particles from lamination residue probably contained a higher proportion of initial wood and a high presence of juvenile wood, which contributed to the reduction in the density value. Another characteristic that may have influenced is related to the

Treatments	D (g/cm³)	U (%)	AA 2h (%)	AA 24h (%)	IE 2h (%)	IE 24h (%)
whole log	0,75 (a) (6,04)	10,81 (a) (1,52)	39,44 (a) (21,71)	56,16 (a) (9,83)	16,14 (a) (13,24)	18,99 (a) (13,73)
rest roll	0,69 (b) (9,10)	10,92 (a) (1,25)	49,78 (b) (4,81)	66,55 (b) (2,58)	22,65 (b) (19,91)	27,04 (b) (10,86)

D: Density (g/cm-3); Humidity: U; AA2h and AA24h: Water absorption in 2 and 24 hours; IE 2h and 24h: Swelling in thickness at 2 and 24 hours. Mean followed by coefficients of variation. Means followed by the same letter do not differ from each other at 95% probability, by Tukey's test.

Table 1: Average value of density, humidity, water absorption at 2 and 24 hours, and thickness swelling at 2 and 24 hours of *P.taeda* wood OSB panels.

tracheids present in the initial wood, which have a lower cellulose content (fibrous region), which may result in a reduction in the density of the OSB panels.

As for particle boards with apparent density between 0.59 and 0.80 g/cm³ are classified as medium density boards (Iwakiri, 2008). Thus, all panels produced in this research fall into this class. The moisture content of the panels showed no significant difference between treatments. The panels met the requirements stipulated by the standard (CSA, 19939, which established moisture content values between 5% and 11%, suitable for commercialization.

Also, according to Table 1, it is noted that the panels made with particles from the leftover roll showed a higher absorption rate (AA) at both evaluated times. This fact may be related to the greater proportion of cells in the initial wood, which contain lumens with greater diameter, that is, greater amounts of empty spaces contain greater amounts of water, since absorption is a physical phenomenon, which occurs due to of capillarity. On the other hand, panels made with particles from the entire log have higher proportions of late wood and smaller diameter lumens, which makes it difficult to absorb water.

For the swelling in thickness (IE), the same tendency of the AA was observed. The panels made with particles from the rest roll (T2) showed greater swelling in thickness. As swelling is a chemical process, it is assumed that this property was influenced by the greater number of cells in the initial wood, which have thinner walls, facilitating the translocation of water through the cell wall in the internal structure of the panels.

It must be noted that the standard (NBR 2006) does not specify values for the AA, however, it can be inferred that the values found for the produced panels were compatible with literature data. [1] produced OSB panels, with 35-year-old Pinua Taeda particles and the same particle ratio (30:40:30). They used FF resin. The pressing parameters were: pressure of 35 kgf/cm², temperature of 180 °C and pressing time of 10 minutes. The authors obtained mean values of 39.52 and 16.50% for AA 2h and IE 2h, respectively. The values were similar to those obtained in the present study (Table 1). For AA 24h and IE 24h, the values corresponded to 64.21 and 22.63%, therefore, they were higher than those obtained in this research. The norm (CSA 1993) establishes a maximum value of 10% for EI after 24 hours of immersion in water. In this sense, the panels showed values above the maximum limit stipulated by the standard.

MECHANICAL PROPERTIES

The results obtained for the mechanical properties of the panels are shown in Table 2.

Treatments	Internal Connection (kgf/cm2)
whole log	7,06 a (26,37)
rest roll	8,25 b (16,63)
Standard CSA 0437 (1993)	3,45

Mean followed by coefficients of variation. Means followed by the same letter do not differ from each other at 95% probability, by Tukey's test.

Table 2. Average values of internal connection of OSB panels.

Regarding the internal connection property of the OSB panels, it is observed that there was a difference between the treatments (Table 2). The OSB panels made with wood particles from the rest roll showed better bonding quality, probably due to the characteristics and origin of the wood particles. The wood particles with a higher proportion of initial wood tracheids allow a greater absorption of the phenol formaldehyde resin, due to the larger diameter of the fire and empty spaces, providing a better connection between the wood particles. Similar behavior was observed for OSB panels by other authors [Surdi et al. 2015 and ASTM 2016]. The OSB panels of the 2 treatments showed values higher than those indicated by the Standard (CSA 1993), as shown in Table 3.

Table 3 presents the mean values of the properties of the OSB panels for the modulus of rupture and modulus of elasticity in the parallel and perpendicular directions.

According to the data described in Table 3, it is observed that the MOR in the parallel direction and the MOE in the perpendicular direction were statistically equivalent in both treatments. In relation to the parallel MOE and perpendicular MOR, significant differences were found, as the panels made with the whole processed log showed higher values for these properties. In part, this can be explained by the higher proportion of late wood found in the particles and in the type of tracheids, which contain a higher cellulose content, resulting in greater strength in the specimens.

The mean values of the mechanical properties of this research were consistent with those obtained by (Surdi et al. 2015) All the mean values of the technological properties for both treatments were higher than those specified by the Standard (CSA 1993), therefore it is recommended the use of lamination residues in the production of OSB panels.

Type of particles	Parallel Flexion		Perpendicular Flexion	
	MOR	MOE	MOR	MOE
	(Kgf cm^{-2})			
whole log	377 (a) (37,20)	78940 (a) (25,64)	201 (a) (36,26)	18346 (a) (33,81)
rest roll	286 (a) (36,26)	48028 (b) (25,25)	172 (b) (16,87)	14313 (a) (13,09)
Standard CSA 0437	O1 – 234 O2 – 290	01 – 45000 O2 – 55000	O1 – 96 O2 – 124	O1 – 13000 O2 – 15000

Mean followed by coefficients of variation. Means followed by the same letter do not differ from each other at 95% probability, using Tukey's test.

Table 3. Average values of the properties of OSB panels, for the modulus of rupture (MOR) and modulus of elasticity (MOE) in the parallel and perpendicular directions of the panels.

CONCLUSIONS

There was an effect of particle origin on all physical properties, with the exception of moisture content. All panels were classified as "medium density". The panels produced with particles from the leftover roll showed higher rates of AA and IE. The EI was higher than recommended by the standard used (NBR 2006).

All average values of technological properties, for both treatments, were higher than those specified by the Standard (CSA 1993), therefore it is recommended to use lamination waste in the production of OSB panels.

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